Research and Career Opportunities for young scientists in Industry. Examples at RI Research Instruments

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RI Research Instruments GmbH

RI Research Instruments GmbH

Development, production and sales of rf accelerator components and systems and special manufacturing projects.

- Former activity of Interatom/Siemens (80‘s to mid 90‘s) and ACCEL Instruments (mid 90‘s to 2009)
- More than 3000 Person Years of accumulated Know How and about 0,4 Bio € of business volume since 1985
- About 170 Employees, 30% Engineering & Project Management, 60% Manufacturing

- 51% of shares by Bruker EST, Inc.
- RI management holding a significant equity stake of the company

- Worldwide acknowledged as an advanced technology engineering and manufacturing specialist

Technologies, „Products“ and Markets

research instruments

Quality Management certified according to DIN EN ISO 9001:2008, KTA

Technologies

- RF, Accelerator, Electromagn
- Superconductivity
- Cryogenics, Vacuum
- Precision Manufacturing
- Surface Treatment , Coating
- Metal Joining
- System Integration
- Integrated System Control

Projects / Products

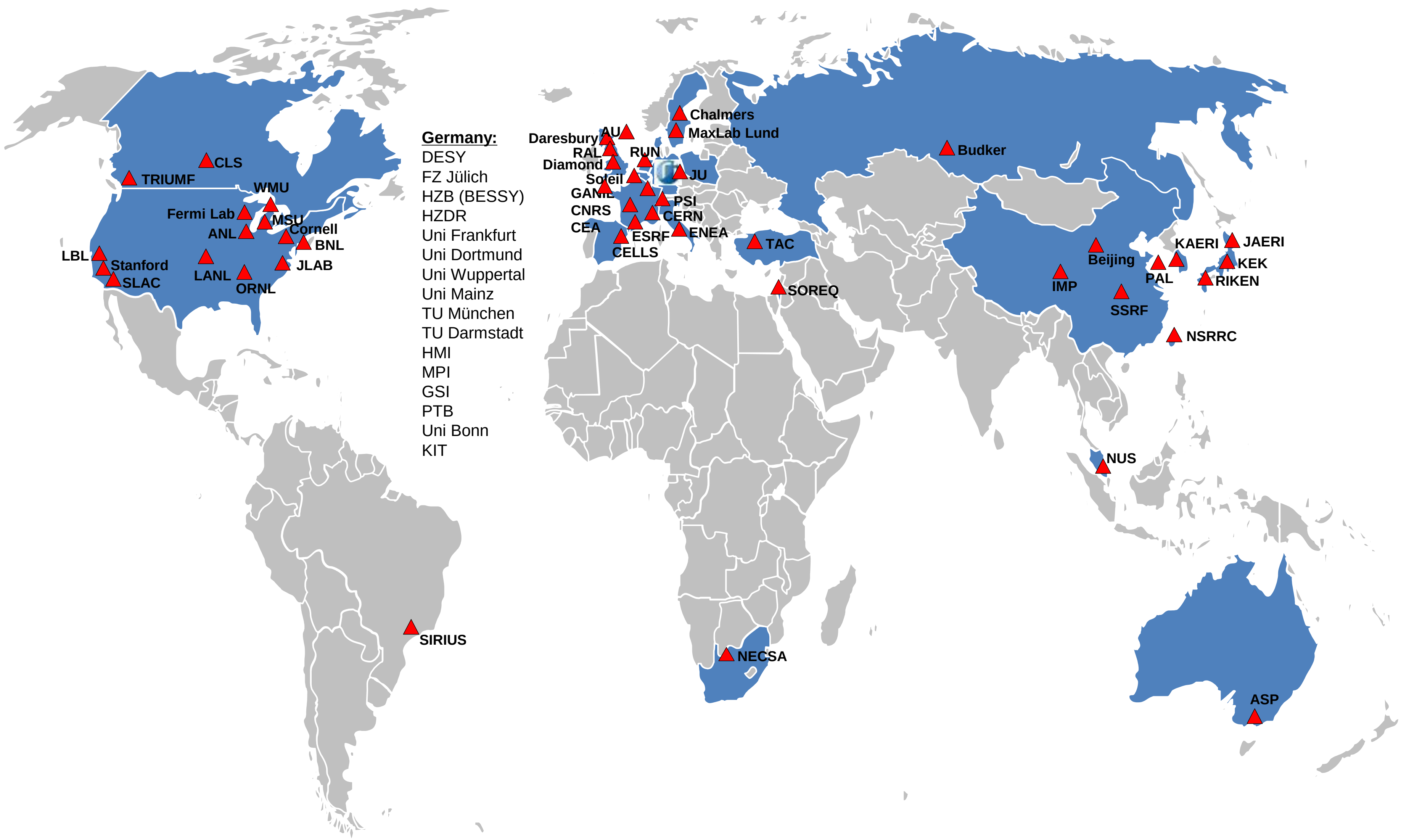
- Linear Accelerators
- Accelerator Modules
- RF Cavities, Couplers
- Particle Sources
- Beamlines and Diagnostics
- Special Manufacturing Projects

Markets

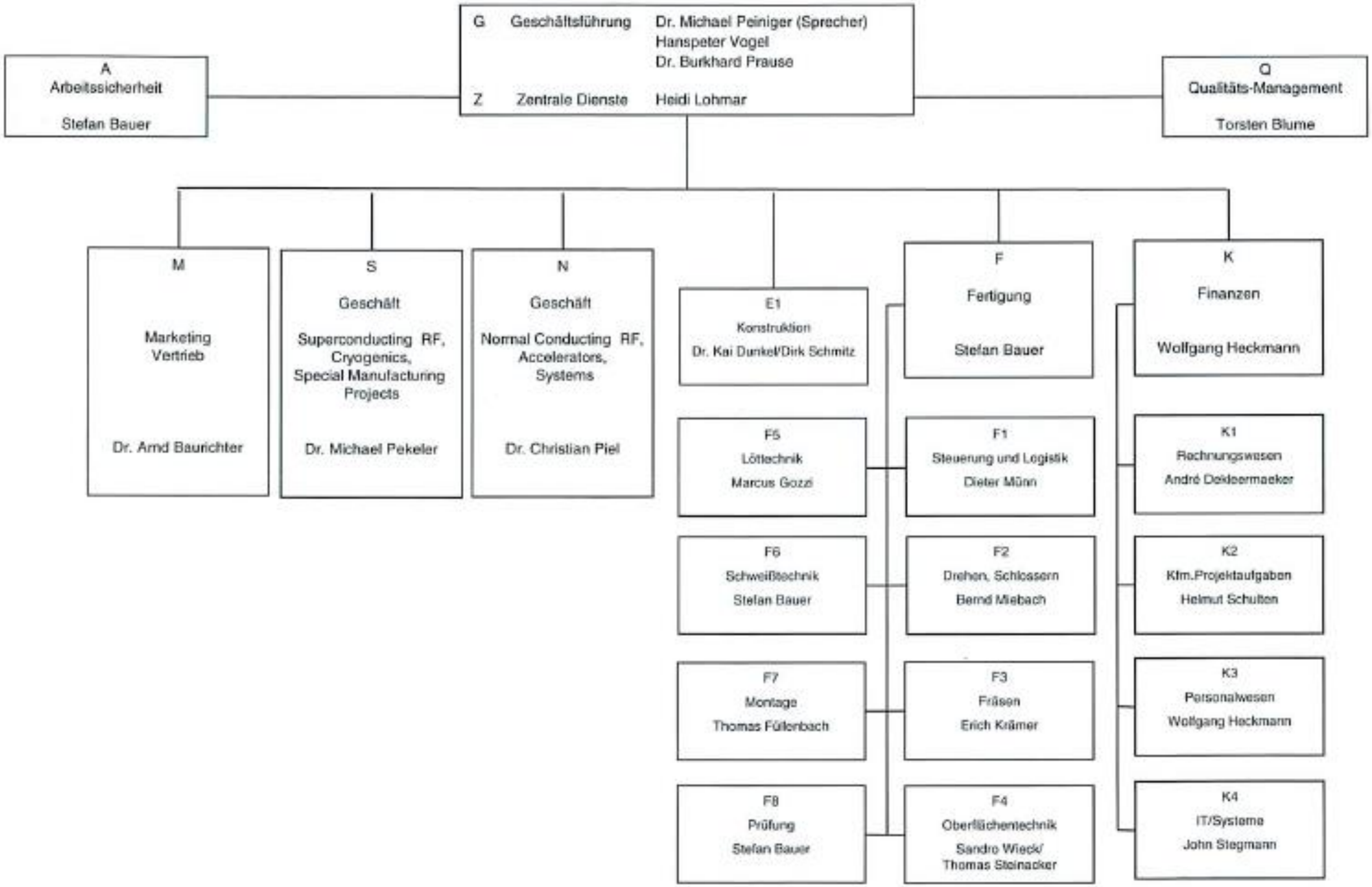
- Big Science
- Medical/ Particle Therapy
- Energy/ Nuclear (incl. Fusion, ADS, Transmutation)
- Advanced Technology Industry (incl. Inspection, Life Science)

project management - physics layout - engineering - manufacturing – assembly – testing – service

World map of customers and partners



RI Company Organisation



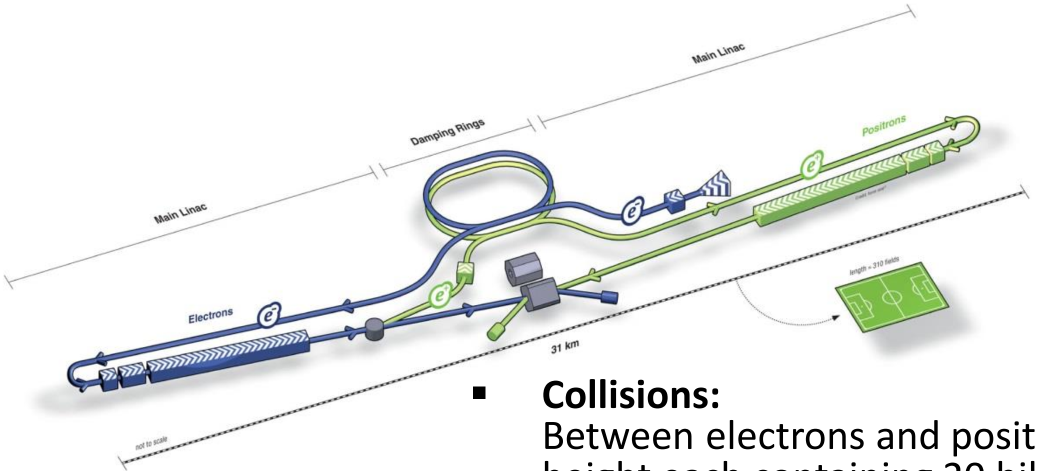
Research Opportunities for young scientists in RI Research Instruments

RI, a company specialized in design and production of accelerator components and systems. We cover the range from basic design investigations, through detailed design (including beam dynamic, rf, mechanical, thermal,…), manufacturing, assembly, test, and installation.
The examples and case studies given today should be seen on the background of these activities.

Outline of this presentation:

- Case study I: A work for master degree regarding manufacturing logistics
- Case Study II: PhD work with the subject of a neutron gamma beam cargo inspection system
- Case Study III: A cryogenic redesign of a srf accelerating module
- Conclusion and thoughts to be discussed

Case study I: series production of Superconducting RF Cavity Production. The ILC



The International Linear Collider in short description

- **Collisions:**
  Between electrons and positrons, in bunches of 5 nanometres in height each containing 20 billion particles and colliding 14,000 times per second
- **Energy:**
  Up to 500 billion electronvolts (GeV) with an option to upgrade to 1 trillion electronvolts (TeV)
- **Acceleration Technology:**
  16,000 superconducting accelerating cavities made of pure niobium
- **Length:**
  Approximately 31 kilometres, plus two damping rings each with a circumference of 6.7 kilometres

All data taken from the ILC website (http://www.linearcollider.org/ILC/What-is-the-ILC/Facts-and-figures)

Case study I: the European XFEL Superconducting Linac Cavity Production

Key components of linac:
800 superconducting RF cavities, 800 RF couplers

Case study I: the European XFEL Superconducting Linac Cavity Production

Order for 300 cavities received from DESY in September 2010
Order for additional 120 cavities received in March 2013
Finish delivery

Niobium and helium vessel supplied by DESY

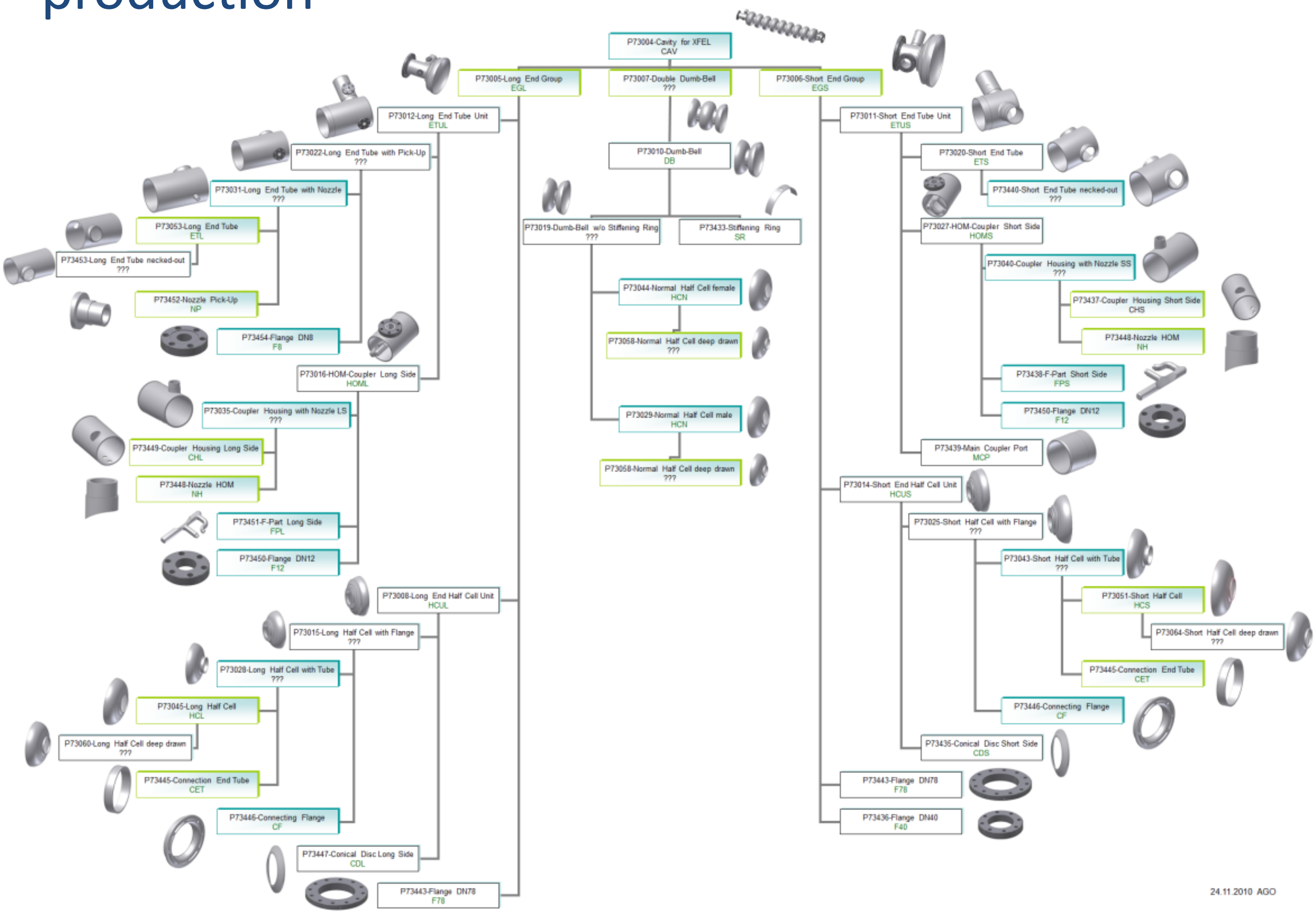
Industry scope:

- Mechanical manufacturing of cavity, respecting the pressure vessel code
- Complete Surface preparation and helium vessel welding
- Shipping to DESY under vacuum and "ready for cold RF test"
- Extensive documentation and QA is crucial and will ensure that cavities are manufactured and treated according to detailed DESY specification.

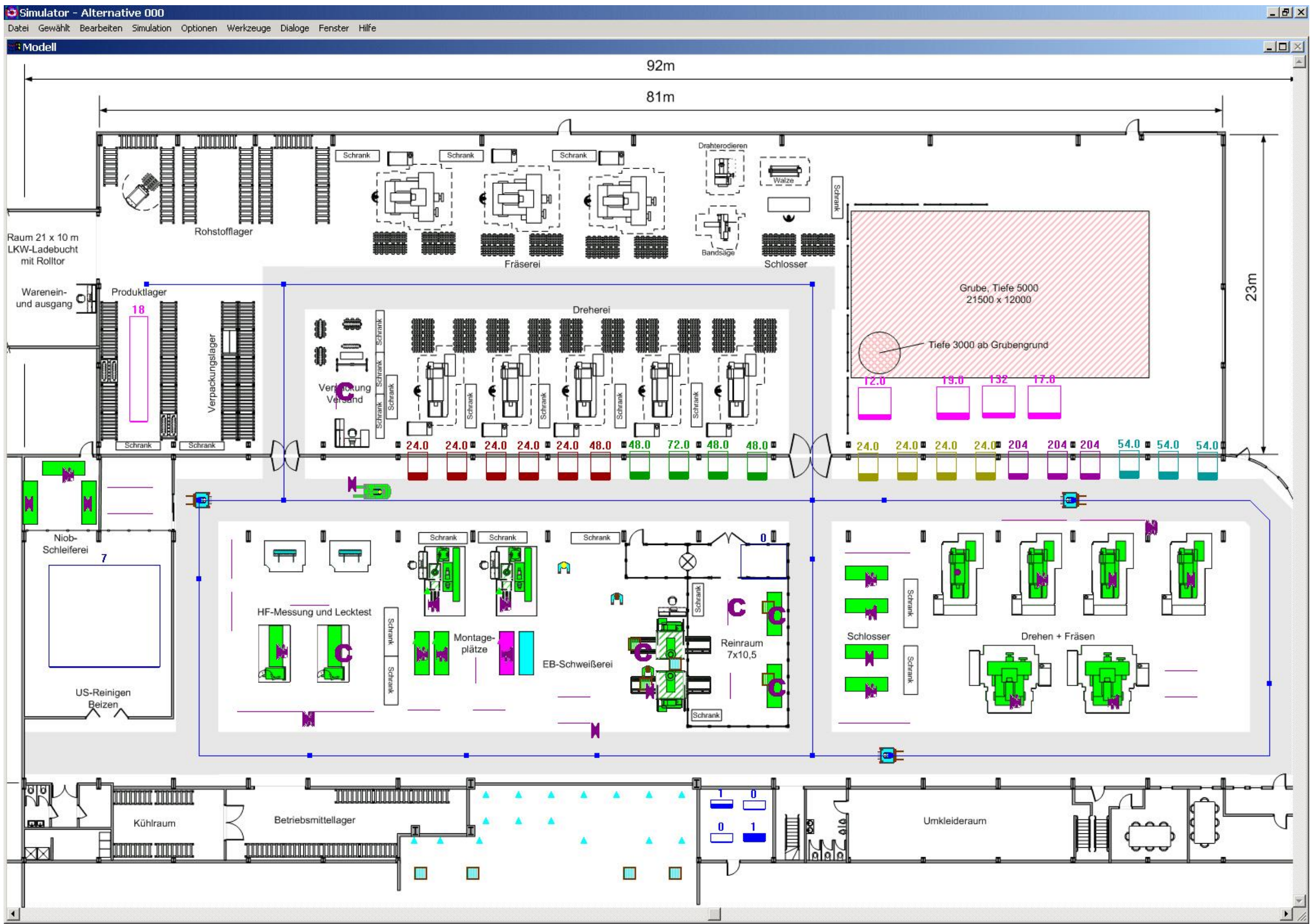
DESY:

- Cavities will be cold RF tested at DESY (vertical test) with helium vessel already welded
- After successful test, DESY will ship the cavities under vacuum to CEA for module assembly

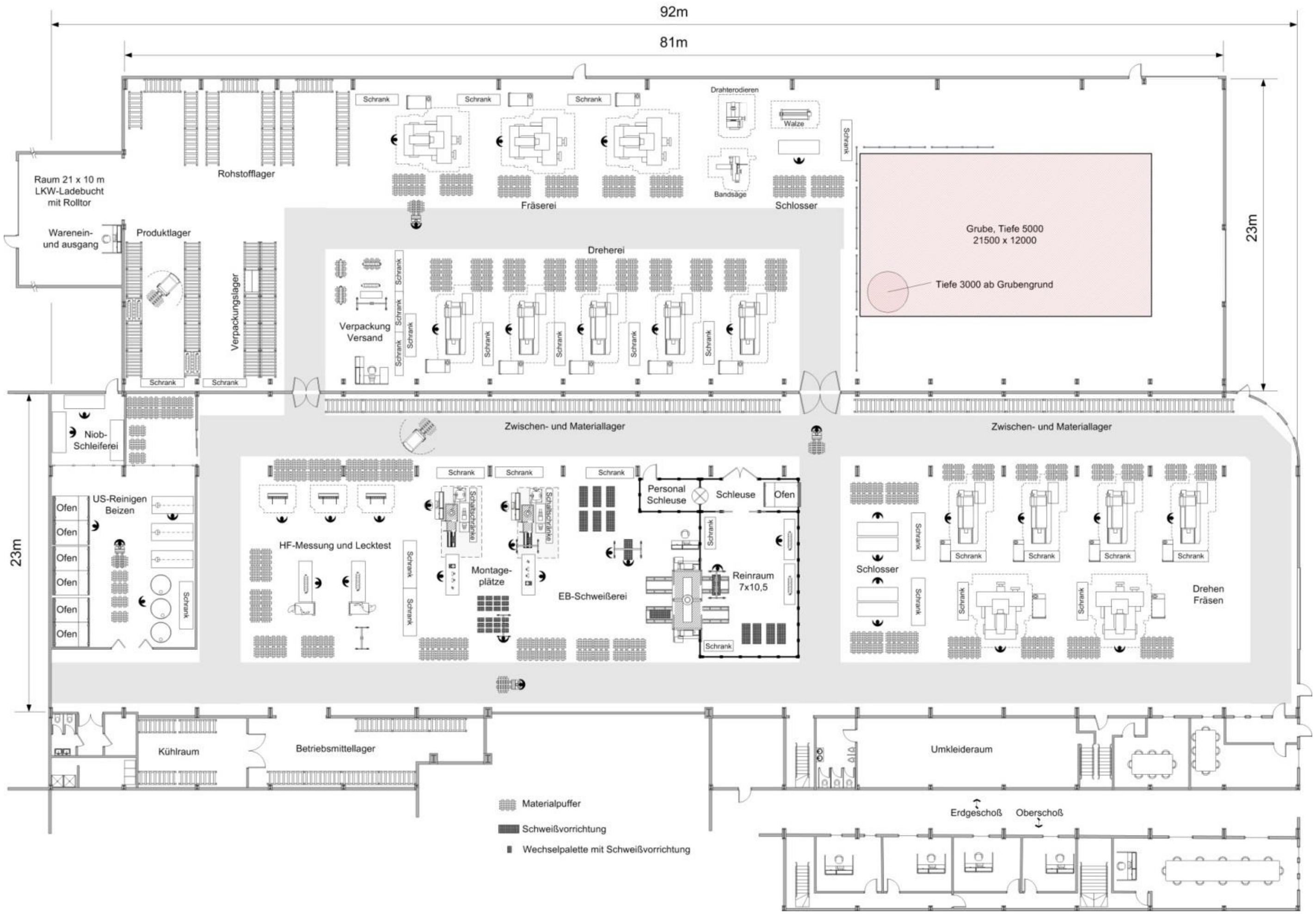
Case study I: simulation of series production



Case study I
Snap shot of simulation



Case study I
Snap shot of fabrication plant layout



Case study I: Summary

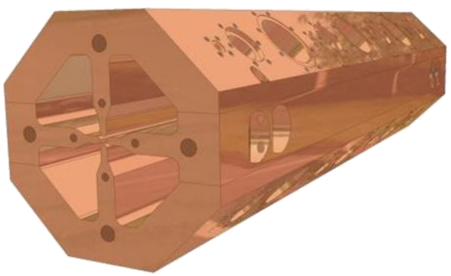
- The master work “Manufacturing concept for series production od Niobium cavities” analyzed the needed fabrication equipment and logistics for the fabrication of 1000 or 500 cavities within one year.
- The thesis explains, based on the given delivery schedule, how to reach the output rate and how much manufacturing equipment is needed. The main focus was on the high investment machines, especially the EB-welding machine to check for bottle necks.
- To check the calculated number of machines a simulation software was used to proof that the layout will be sufficient to gain the production rate.
- Finally the data have been used to plan the manufacturing of the XFEL cavities at RI. A total of 400 cavities is now produced at a rate of 16 cavities per month.

Case study I

After completion of his degree our colleague continued working at RI Research Instruments and managed projects such as Assembly of superconducting accelerating modules.
Today he is managing complex and “one of a kind” superconducting experimental systems such as the WGTS for the KATRIN experiment at KIT (Forschungszentrum Karlsruhe)

The WGTS during assembly comprises cryogenic, vacuum, precision-manufacturing, and -alignment technologies

Case study II:
Generation and Characterization of a pulsed, intense Neutron- and Gamma Beam to be employed in Air Cargo Interrogation

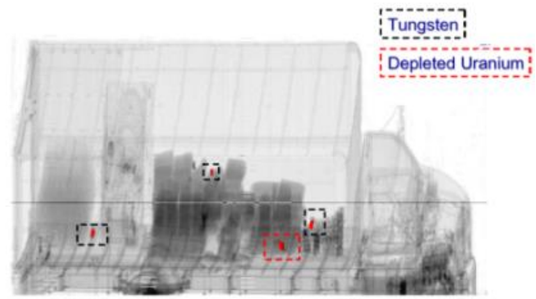


RI participates in a research program ACCIS aiming at developing a neutron and gamma based air cargo inspection system to automatically detect explosives as well as special nuclear material. This bi-national German-Israeli research project was funded by the German Bundesministerium für Bildung und Forschung (BMBF) as well as the Israeli Ministry of Science and Technology (MOST). The collaboration consist of the PTB, BAM, RI, Roentdek and the TU Berlin as well as the Israeli Institutes Soreq Nuclear Research Center and the Weizmann Institute.

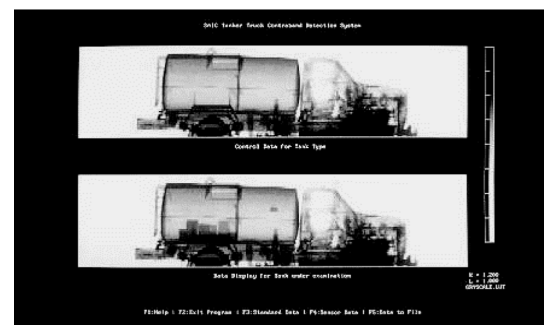
Existing Explosives Detection Systems (EDS) based on X- and γ-Ray:

Low energy
(450 kV) X-ray

High energy
(6-9 MV) X-ray



Gamma-rays
(^{137}Cs, ^{60}Co)



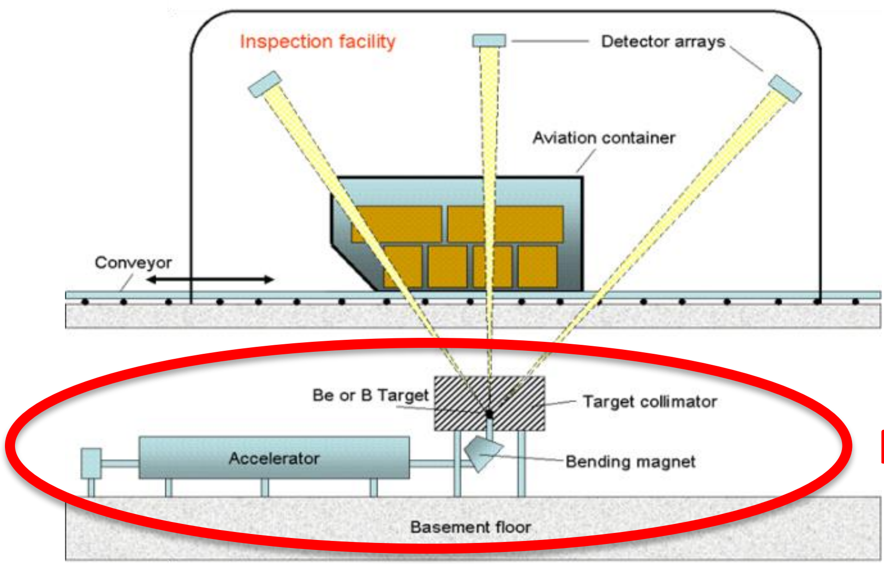
- Non-specific to explosives or special nuclear material (SNM)
- Only manual pattern-recognition based on operator skills is possible

Automatic Cargo-Container Inspection System (ACCIS)

$^{11}B(d,n+\gamma)^{12}C$ – Deuteron Energy 3-8 MeV

4.43, 15.1 MeV γ-rays
Dual **D**iscrete **E**nergy
Gamma **R**adiografie
=> SNM detection

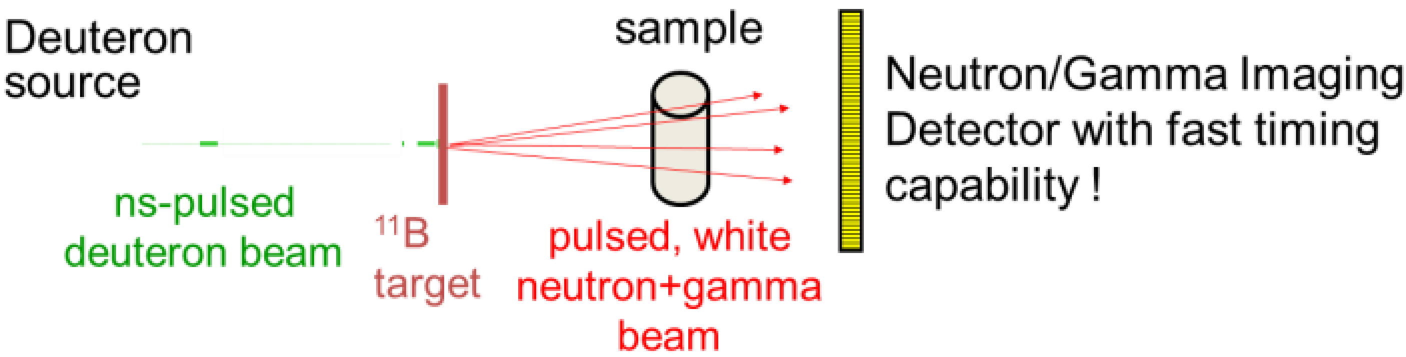
0-17 MeV neutron spectrum
Fast **N**eutron
Resonance **R**adiografie
=> Explosives detection

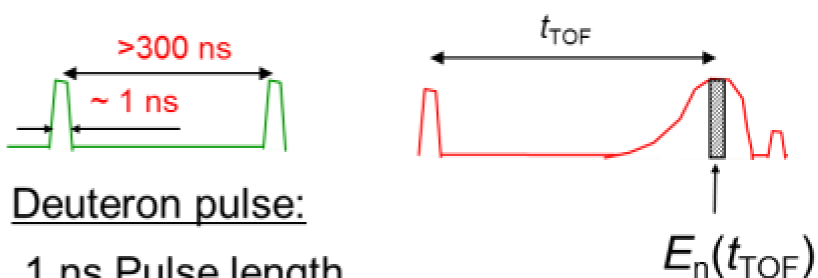


PhD Work

- (Semi-) Automatic Inspection
- Isotope specific Detection
- Combined Explosives & SNM Detection

Essential: TOF Capabilities





$$E_N = \frac{m_N d^2}{2 \cdot t_{TOF}^2}$$

Deuteron pulse:

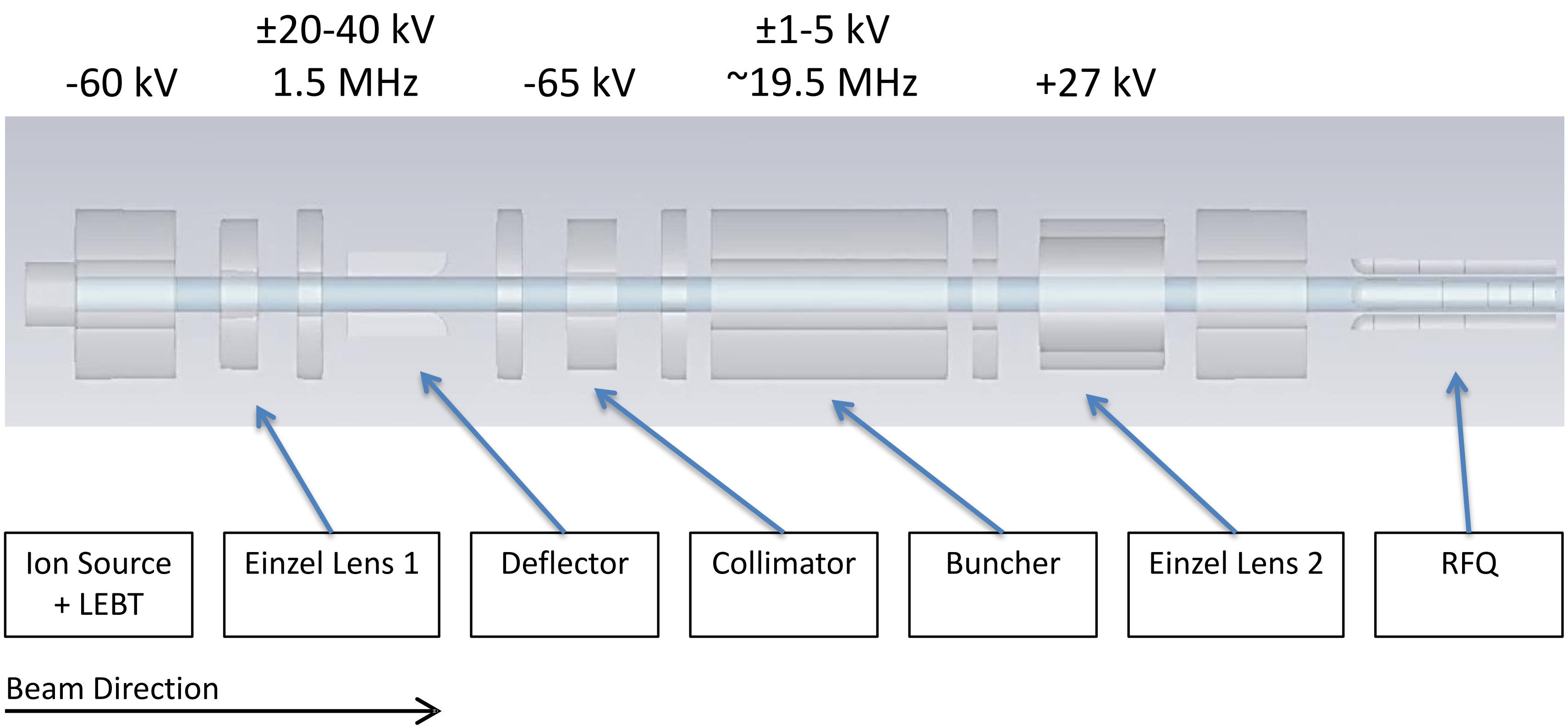
1 ns Pulse length

>300 ns Pulse distance

→ Time-of-Flight (TOF) determines neutron energy and discriminates n/γ

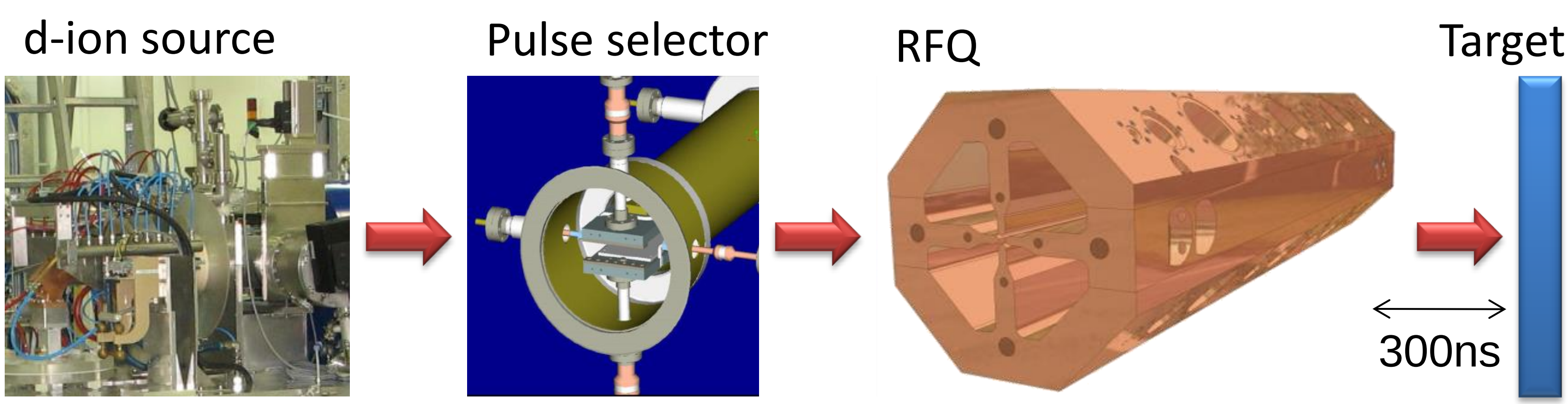
→ 2 MeV Neutrons need ~300 ns for 6 m

Schematic Design of the accelerator



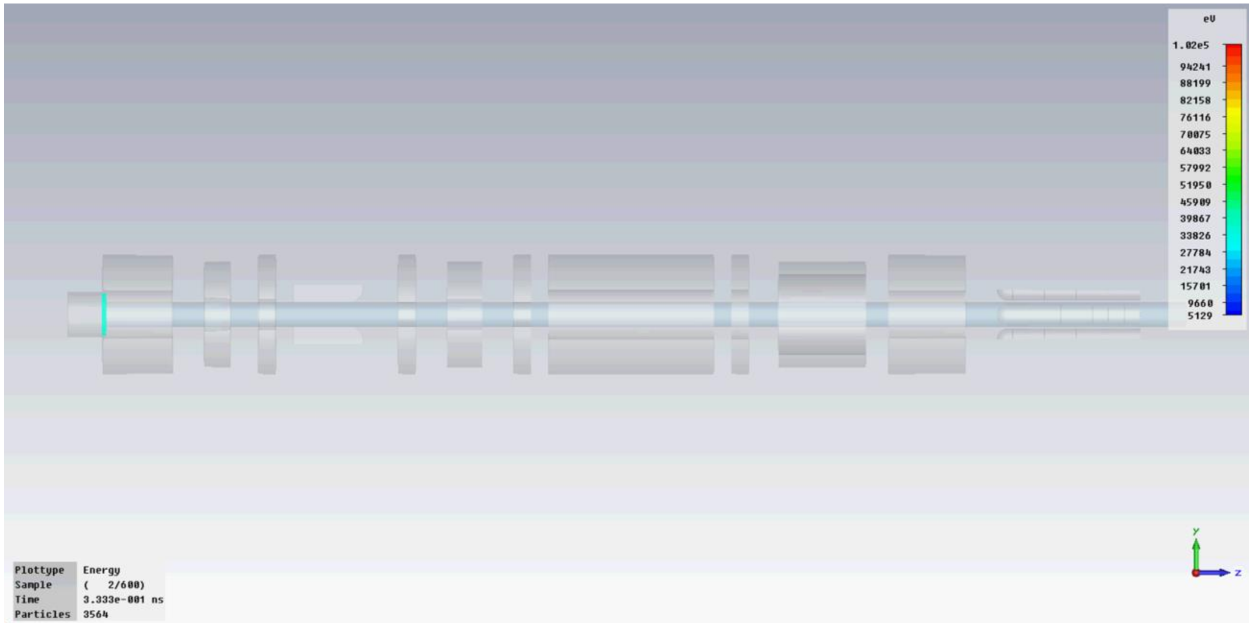
System Parameters & Pulsing Concept

- Required deuteron energy 5 - 7 MeV
- Focal spot < 5 mm (to detect thin-sheet explosives)
- Timing structure (1 - 2 ns pulse width, < 3 MHz rep. rate)
- Required deuteron current ~ 600 µA (time average) or ~ 200 pC (per bunch)
- Possibly compact and light weight (mobile or locatable)



research instruments

Beam Dynamics Simulation

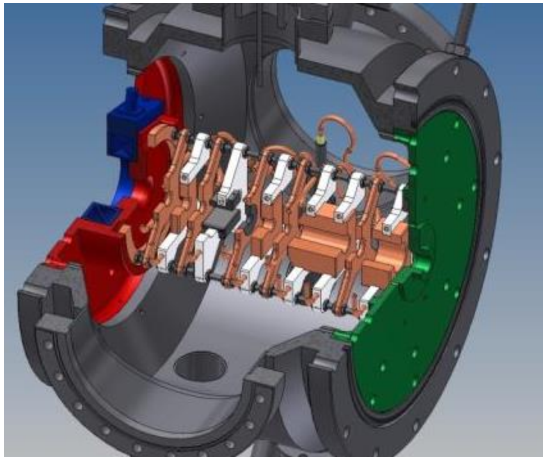


The Thesis work comprised:

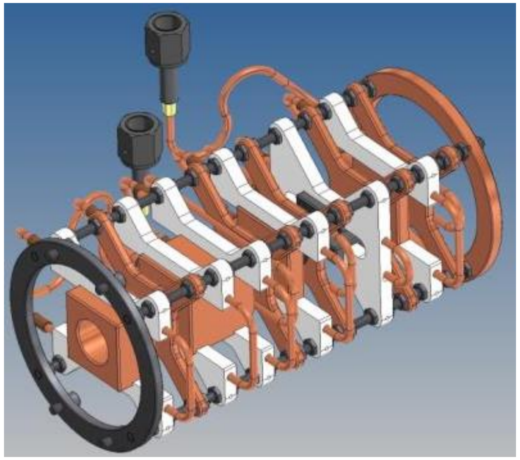
- Beam Dynamics Design and Simulation of ns-pulsing system
- Setup of a test-bench (Ion Source + LEBT + Diagnostics)
- Ion beam tests of pulsing system

CAD Modeling & Manufacturing

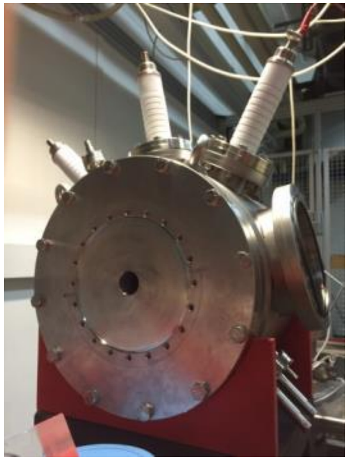
Exterior view



Interior view



Inlay



Case study II

The specific tasks of this PhD work in detail:

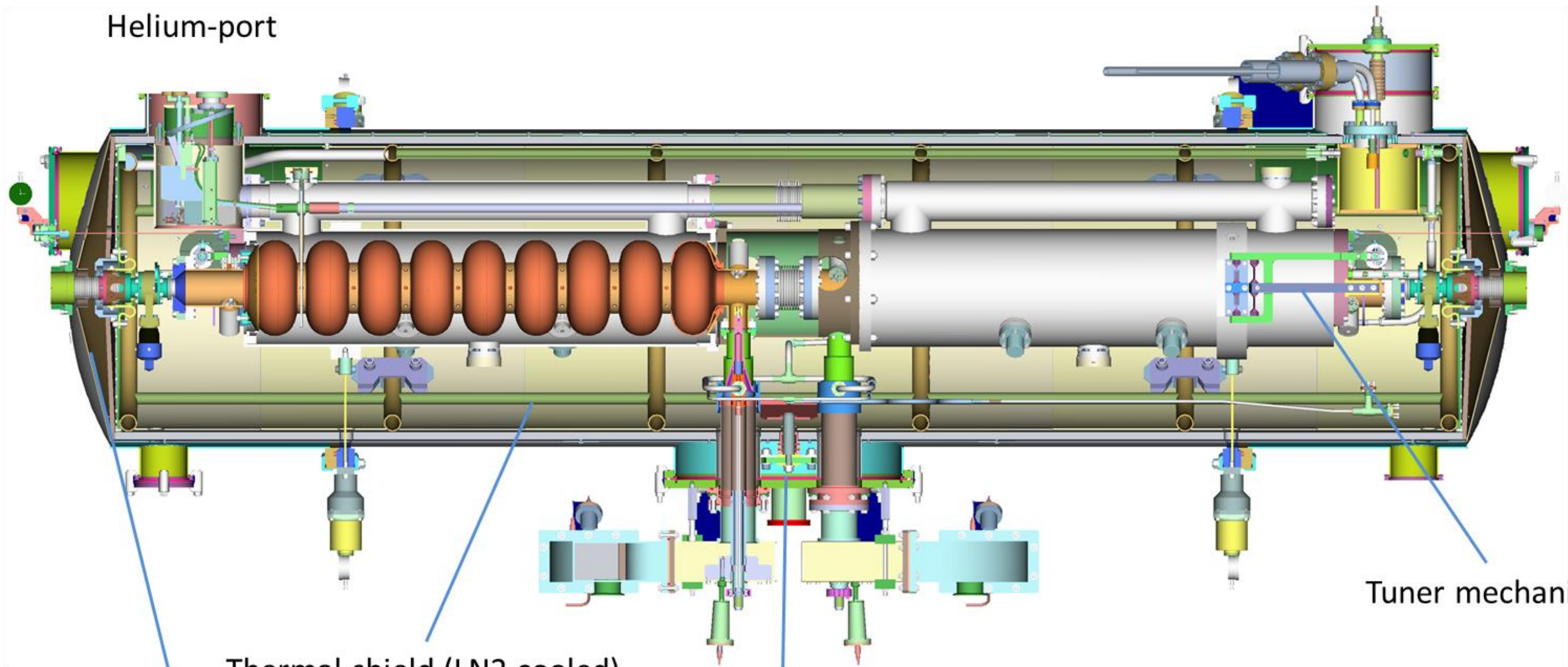
- Perform Beam Dynamics Design and Simulation of ns-pulsing system
- Match the accelerator design as the source for production of n, g –rays to the requirements of the detector system.
- Oversee the manufacturing of a pulser system in RI workshop
- Setup of a test-bench (Ion Source + LEBT + Diagnostics)
- Perform measurements of pulsed beams in PTB. Ion beam tests of pulsing system
- Manage and keep track on all aspects during development of the accelerating system.

Case study II: Timetable

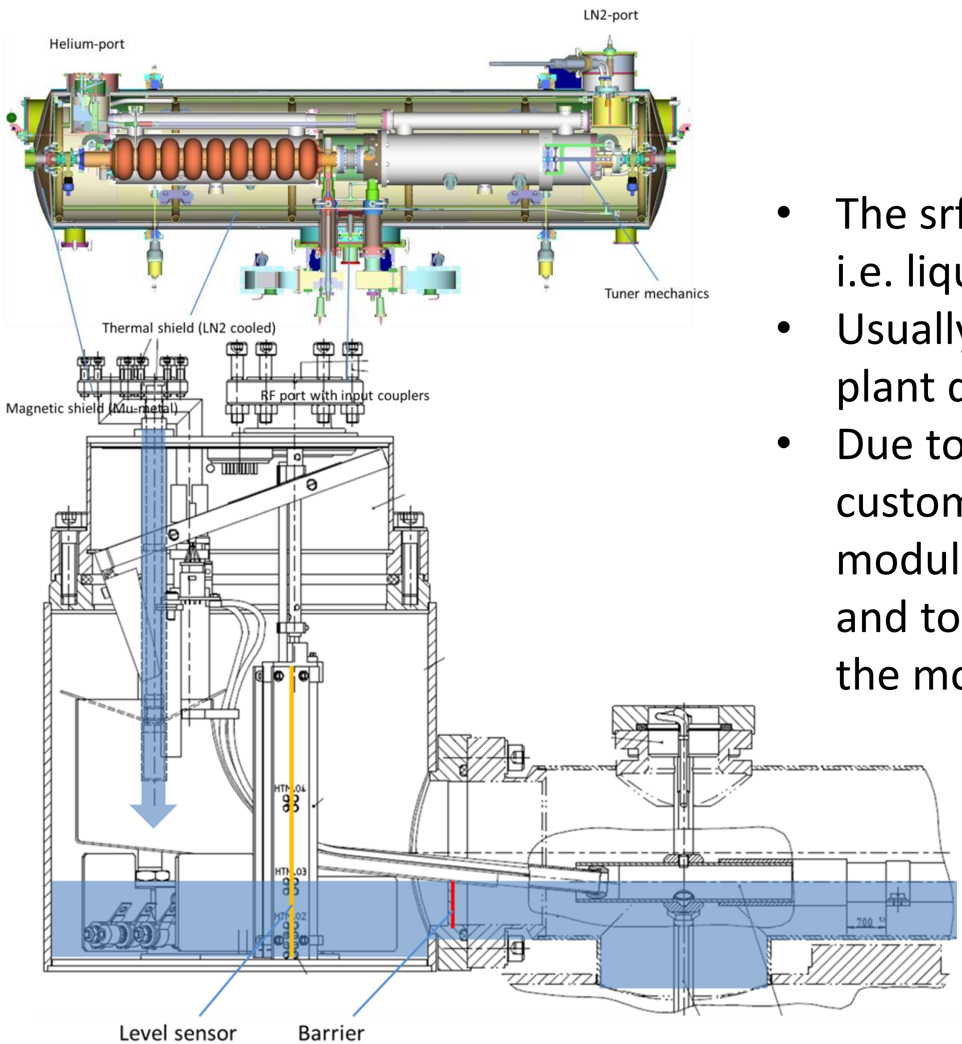
June 2011:	First idea of shared PhD project
December 2011:	Finalization of formalities
March 2012:	Start of PhD work
November 2012:	Final technical design of pulsing system
Mai 2013:	Final design review
March 2014:	Mechanical assembly
April 2014:	Electrical assembly
Since June 2014:	Ion beam tests
~March 2015:	Completion of PhD work

- In parallel: Design study for dedicated RFQ accelerator for the Korean IBS project research instruments

Case Study III
cryogenic redesign of a srf accelerating module



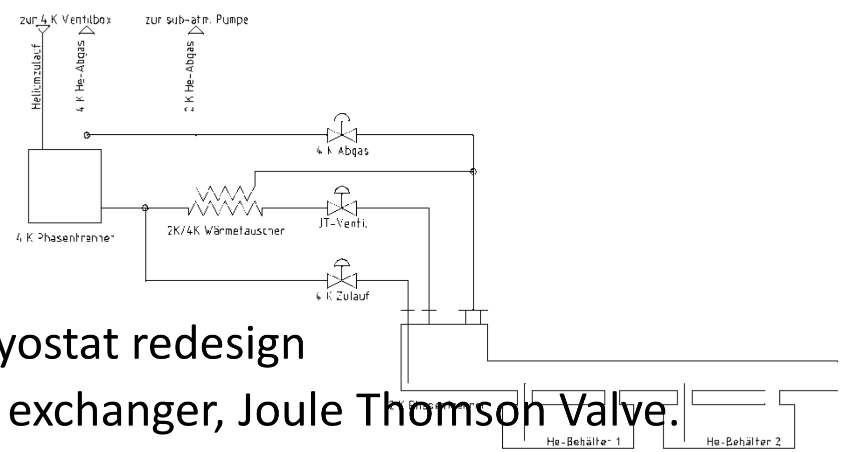
Case Study III
cryogenic redesign of a srf accelerating module



- The srf module is designed for a 2K operation, i.e. liquid Helium at 30 mbar pressure
- Usually this LHe is supplied from a cryogenic plant directly
- Due to the specific boundary conditions at the customer it is considered to supply the srf module with LHe at ambient pressure (4,5K) and to integrate a Joule Thomson Valve inside the module/cryostat

Case Study III
cryogenic redesign of a srf accelerating module

- 4 K Helium supply existing at the customer (Uni Mainz)
- 4 K Valve box, to be supplied
- Sub atmospheric pumping station existing at customer (Uni Mainz)



The specific task would be the cryostat redesign
 to include phase separator, heat exchanger, Joule Thomson Valve.

- Basic design consideration
- Exchange and validate desing with external experts
- Coordinate and manage realization of the redesign
- Coordinate with customer

Case Study III
cryogenic redesign of a srf accelerating module

Typical tasks in this context:

- **Basic design considerations:** The design phase will start with a conceptual design covering the required valves and pipework and the mechanical integration of the components. In the next step the design parameters such as pipe diameters and valve geometries have to be calculated to fit the required flow scenarios for cooldown, operation and warm-up.
- **Exchange and validate design with external experts:** External experts are available for consultation during the design phase and will cross-check the calculations prior to the release for manufacturing.
- **Coordinate and manage** realization of the redesign
- **Coordinate** with customer
- A young researcher with some background in cryogenics or thermodynamics in general would support the RI design team for this task.

Summary: some careers at RI

- PhD on electron linear accelerator: now head of business division
- Master Thesis of manufacturing logistics: now Project Manager
- Master Thesis on analysis of our suppliers data base: now Project Manager
- Master Thesis on the IT aspects of a suppliers data base: responsible IT person (in another company)
- PhD on ACCIS: tbd.
- Master/PhD on cryogenic aspects of a srf accelerating module: tbd.

Summary: Some aspects on these scientific works in industry

Some thoughts for discussion:

View of the candidate (contributed by our colleagues):

- Work in an industrial environment
- Learn to acknowledge the “customers needs”
- Learn to work to a time schedule
- Experience detailed exchange with many or all company groups/departments
- Learn to solve complex problems with dedicated special solutions
- Expand knowledge over the learned at university
- See own ideas become real products
- Learn that theory is not always directly implementable to real work life.

Summary: Some aspects on these scientific works in industry

Some thoughts for discussion:

View of the company (my thoughts):

- Have a dedicated and eager person for the project
- Achieve R&D goals (in time)
- Have support from research labs or universities, build networks
- Learn the candidate's personality in detail for eventual future tasks

Summary: Some aspects on these scientific works in industry

There are more development projects and future opportunities than presented here.
Some of them are confidential as they will be used in industrial applications, such as novel concepts, were accelerators serve as production tools

Thank you for your attention!